GEODETIC CONTROL GAINS IMPORTANCE AS MISSILE ACCURACY IS INCREASED

World Geodetic System developed by USAF relates positions of missile launch sites and targets. Data is lacking on many targets

TODAY'S long-range guided missiles, fired for distances of several thousand miles, may not be expected to hit the target right on the nose, but they are expected to come reasonably close. A pitcher with the best fast ball in the world is useless if he can't get it near the plate. Without the element of control, an IRBM or ICBM is rendered ineffective as a weapon system.

Each missile type produced has its own inherent or built-in error, probably ranging from several thousand feet to several miles, according to the missile. This is known as the missile's circular error probability (CEP), a combination of human error, mechanical error, and the weather factor. Naturally, every effort is being made to reduce this error, in order to reduce the number of missiles required to achieve complete destruction of the target. But no matter how much the missile CEP is reduced, the missile will not achieve complete accuracy if the positional data that determines the trajectory is faulty.

The accuracy of this positional data for the missile is, in turn, dependent on the available geodetic control and the ability to use it. Actually, the geodetic data presently available can position about 80 percent of potential targets in the Soviet Bloc to an accuracy of 2,000 feet. The data available on the remaining 20 percent, however, gives an accuracy only of from 2,000 feet to an unknown quantity. What is worse, many important targets are included in this group.

Geodetic error relates directly with the missile CEP. The method of determining exactly how much is basically simple. Both the geodetic and missile errors are squared; the square root of the sum of these squares represents the total missile error. This is illustrated by the graph on next page. In a family of missiles with large CEPs, the geodetic error is not significant. In fact, when the geodetic error is less than 30 percent of the missile CEP, an additional error of only five percent or less occurs. But as missile CEPs are refined, the geodetic error will naturally assume an increasingly greater prominence.

For example, let's assume that for a certain ICBM the CEP and geodetic error are each 5,000 feet. This would result in a total expected error of some 7,000 feet, not bad if the target happens to be a large area. However, in order to achieve a lengthy pindown of an enemy ICBM launching base, the missile CEP may be refined as low as, say, 1,000 feet, which would be a tremendous achievement. But unless the geodetic error is reduced, the missile would still have a total error of over 5,000 feet.

What is geodesy?

Until recently, the science of geodesy was used mainly as a support of the mapping industry and was still unfamiliar to operational personnel. This situation changed rapidly as weapon systems whose employment is dependent on geodetic control became operational. Geodesy is defined by Webster as "that branch of applied mathematics which determines, by observation and measurement, the exact positions of points and the figures and areas of large portions of the earth's surface, or the shape and size of the earth and the variation of terrestrial gravity." More simply, geodesy provides the framework for placing all features on the earth in their correct position. If the geodetic information is good, an accurate representation of the earth's surface can be constructed. Poor geodetic information results in an inaccurate representation.

It is not difficult to realize why accurate mapping depends on good geodetic information. Imagine trying to sketch even a back yard without knowing the measurements of the lot, position of the house in relation to the lot, and the position of trees, shrubs, flower beds, and gates. Basically, these measurements represent the geodetic control of the yard. Where large areas and greater distances are involved, more accurate equipment and techniques are required. But the basic requirement—accurate measurements between points—remains the same.

In the construction of maps, it is difficult to properly portray the relationship of features in sketches and textual descriptions unless the geodetic control of the area is known.

The task of providing geodetic control has been carried on by geodesists and surveyors for centuries. To control an area, the initial efforts must be made by the surveyor. He has many tools at his disposal, such as

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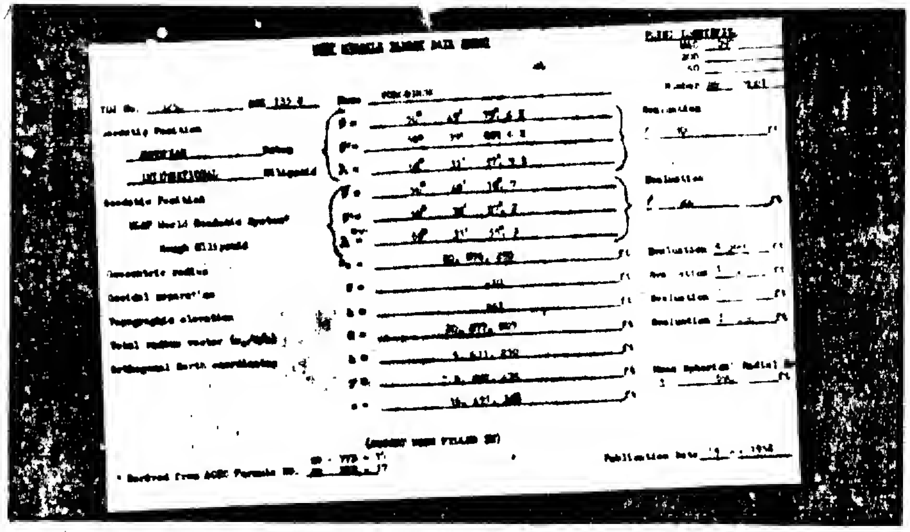

TARGET data sheet (above) shows information used to plot missile path. [CONFIDENTIAL]

transits, steel tapes, geodimeters, theodolites, tellurometers, and gravimeters. These tools permit accurate measurement of distances, angles, gravity force, and celestial observations. For large areas inaccessible to survey parties, electronic devices such as Hiran are used. The data acquired by these methods are then given to the geodesist for resolution.

If the geodetic control problem is limited to a small area, the labors of the surveyor are adequate. But when the area of interest is extended and the curvature of the earth becomes involved, the geodesist is requested to provide a base for compilations.

Using the available data, the geodesist provides a mathematical surface. This theoretical surface is the most accurate representation of the size and shape of the area for which it was prepared. The ability of the geodesist to compute this surface is dependent on his knowledge of the true size and the shape of the earth. As yet, the complete surface of the earth has not been surveyed, so its true size and shape must be estimated from the other data available.

All estimates by United States geodesists have been made thus far on the basis of a figure called an ellipsoid of revolution, which appears to approximate most accurately the general shape of the earth. The true shape of the earth may never be accurately determined, because current measurements of the gravity field indicates a highly erratic shape. However, this ability to measure the earth's gravitational field permits the improvement of relative positions of widely separated points. The effect of gravity on astronomic observations can be minimized, and thus the astronomic positions reflect more accurately a true position of the surface of the earth.

Target vulnerability does not have to rely on the accurate world-wide location of the target. The correct relative positions of individual installations to each other may also permit an analysis of vulnerability. During World War II, knowledge of the relative positions of installations within a target area permitted accurate operational attacks to be made.

Accuracy requirements had not been too stringent up to this time, as manned weapon systems readily compensate for minor errors in charting. However, soon after the war, the accurate position of points outside of the target area became important. Offset bombing and reference point navigation equipment required an accurate knowledge of target locations relative to the offset aiming points or reference points. This extension of the controlled area posed a problem to the chart maker. Specifications for chart production were tightened, and techniques and equipment for chart production were improved.

Missiles changed geodetic requirements

Until 1950, graphics were satisfactory for accurately portraying required geodetic information. In that year, the requirements for missile operations were reviewed, and it became obvious that a unique item of target materials would be needed. At the same time, the operational commands expressed the desire for more accurate control requirements. As a result, the geodetic data sheet program was initiated. The geodetic data sheet furnished the operational commands accurate positional information for use in offset aiming and reference point navigation. They also enabled producers of target materials to develop a capability for working with accurate geodetic control.

There was still a large problem to be solved, however, before the input data requirement for missiles could be met. It was necessary to reflect the most accurate relationship of the launch site to the target on a common frame of reference. To accomplish this, a USAF World Geodetic System was developed. This system provides a mathematical surface which most accurately reflects the size, shape, and orientation of the earth's surface. All points that can be related to the USAF World Geodetic System can also be related to each other. Thus, the position of launch sites on one continent can be related to targets on another continent.

Armed with the positions of launch site and target on a common datum, and the parameters of the datum, a target trajectory computation center could now compute a ballistic trajectory. In 1957, this basic data was incorporated into missile data sheets—one for the launch site and one for the target. Additional data for orientation and calibration are included in the launch site data.

By 1962, the built-in error of the present crop of U.S. missiles is expected to have been considerably minimized. This means that the value of accurate positional data will become even more important and that errors in excess of 1,000 feet will seriously degrade CEPs. There will continue to be gaps in geodetic data for several years, but new reconnaissance systems, together with current programs, should not only extend current control, but should improve the accuracy of present positions. Meanwhile, a survey of control requirements of ultra weapon systems of the future are being conducted. Even the solution to interplanetary travel may well depend on current programs designed to provide accurate positions for all celestial bodies. End

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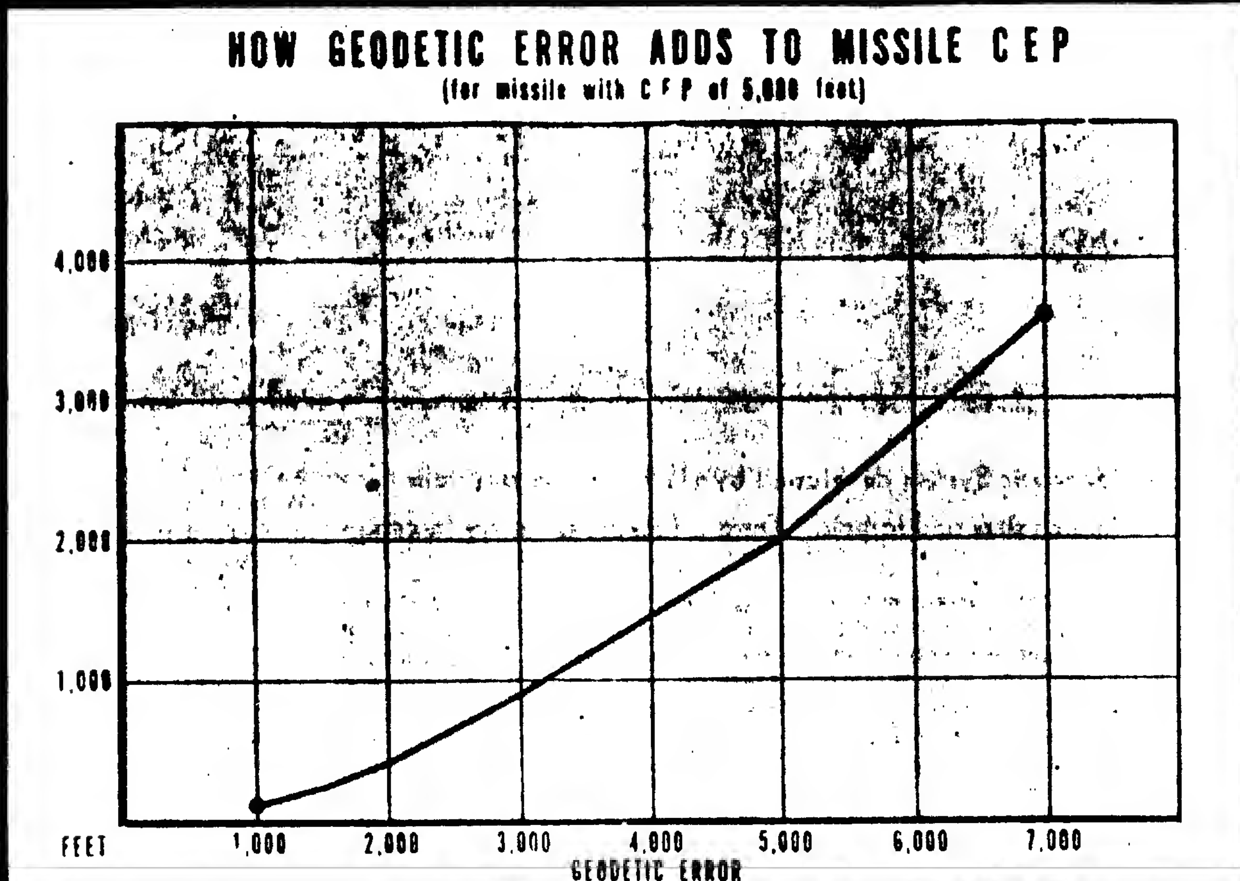
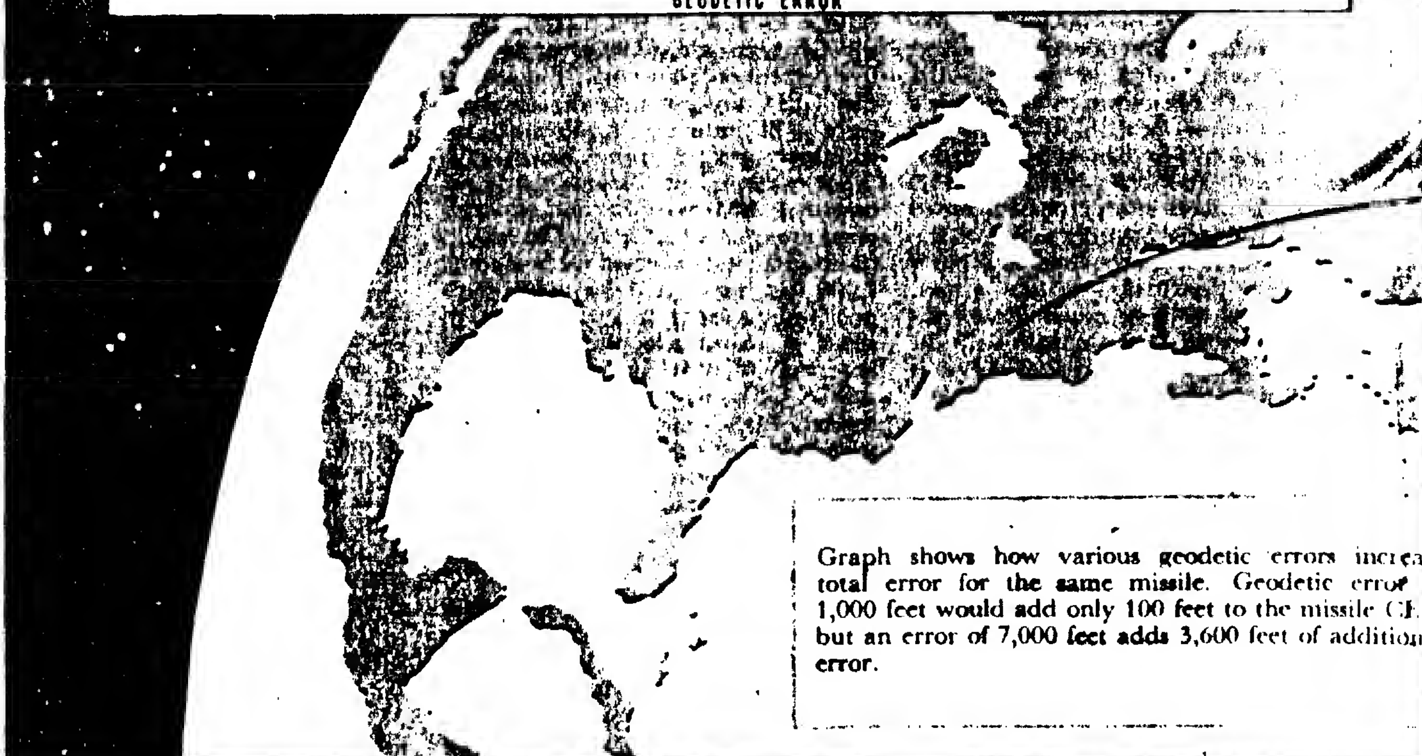
EFFECT OF GEODETIC ERROR ON MISSILE ACCURACY

Attempt to knock out hardened site such as an ICBM base would be made more difficult by a large geodetic error. Illustration shows how a missile with a CEP of 5,000 feet would be affected by a geodetic error of 5,000 feet [SECRET]





Graph shows how various geodetic errors increas total error for the same missile. Geodetic error o 1,000 feet would add only 100 feet to the missile CEP but an error of 7,000 feet adds 3,600 feet of additiona error.

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